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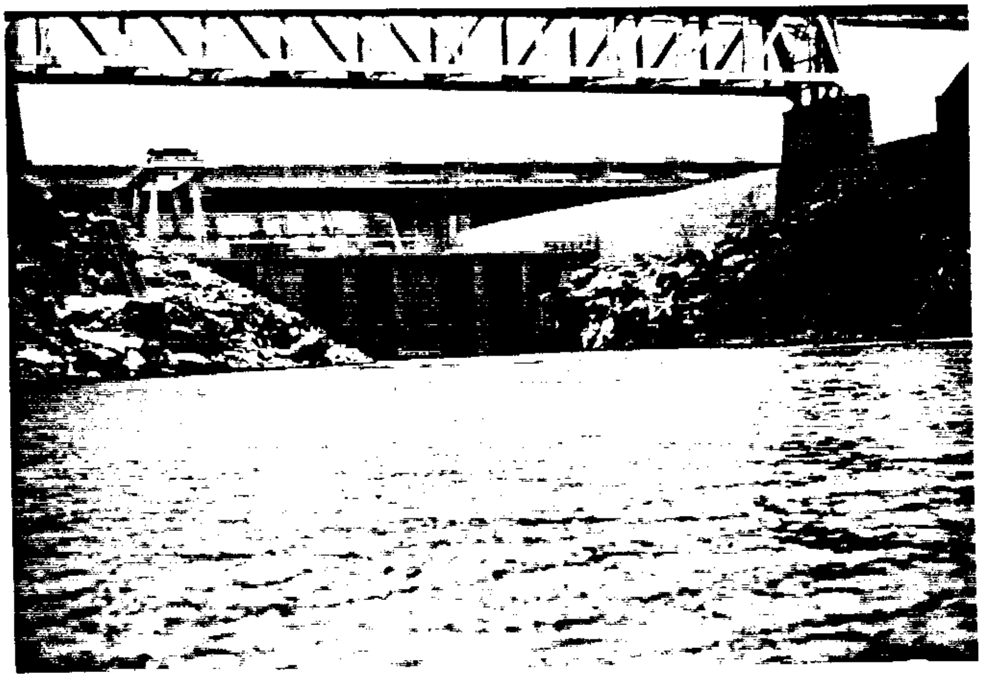
JOB PERFORMANCE REPORT, PROJECT F-71-R-12
LAKE AND RESERVOIR INVESTIGATIONS
American Falls Reservoir Studies
Study III, Job Nos 1 and 2



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JOB PERFORMANCE REPORT

State of: Idaho

Name: Lake and Reservoir Investigations

Project No.: F-71-R-12

Study No.: III

Title: American Falls Reservoir Studies

Job Nos: 1 and 2

Period Covered: March 1, 1989 to February 28, 1990

ABSTRACT

We conducted a study on American Falls Reservoir to describe trout habitat in relation to drawdown, the effect of habitat structure on fish density, habitat loss in relation to outmigration of trout, shoreline habitat available in relation to drawdown, and mortality of rainbow trout passing through American Falls Dam.

Reservoir drawdowns the past two years appear to have a positive, rather than negative, effect on reservoir temperature and dissolved oxygen. As the reservoir pool was lowered, the percentage of volume suitable for trout habitat increased. The reservoir did not stratify during our study. Mixing and inflow probably had a greater influence at lower pool volume.

Artificial structures did not concentrate game fishes during the period we sampled. We conclude that other than trout, few game fishes were present in the reservoir.

Habitat in the form of shoreline vegetation decreased rapidly with water level drawdowns during the irrigation season. However, cover in the form of rocky shoreline is available at all elevational levels.

We estimated a turbine mortality of 34% for fish passing American Falls Dam. Based on turbine mortality, observed growth, and existing recovery rates for trout, we conclude that reservoir stocking provides a better alternative for management of the river fishery than stocking directly in the river.

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INTRODUCTION

American Falls Reservoir is located on the Snake River in Bingham and Power counties. Its primary use is irrigation storage and flood control. The original dam was completed in 1927, and reconstructed at the same location in 1979. Both dams provided the same level of volume, with maximum water level elevation 1,327 m (mean sea level). The new dam and power plant allowed for increased electrical production. Now virtually all of the outflow goes through the turbines rather than over the spillway.

The reservoir covers 22,663 hectares and contains 2097 km^3 of water at full capacity. The U.S. Bureau of Reclamation manages the dam and reservoir. Refill typically begins in October and continues through winter and early spring. Final fill is during the spring runoff. Irrigation use of the water starts in June, and drawdown starts as demand exceeds inflow.

Major annual fluctuations in water level at American Falls Reservoir are the result of irrigation demands. During years of below normal precipitation, as occurred during the period 1987 through 1989, drawdowns were considerably higher than the long-term average. Reservoir game fish populations, especially those requiring shoreline cover, may be stressed by these drawdowns. The effect of drawdown on trout populations is unknown.

Bushnell (1969) assessed water quality in American Falls Reservoir and reported a significant oxygen deficit. The reservoir appears to warm quickly and stratify only weakly. Consequently, we believe that unsuitable dissolved oxygen and temperature conditions could stress trout populations in the reservoir. Marginal temperature and oxygen conditions might be aggravated by drawdown.

Most game fish caught by anglers at the reservoir are hatchery rainbow trout Oncorhynchus mykiss (Heimer 1984). These fish are planted in mid-April at 200-250 mm in length. In the past, release locations have been away from the dam so that fish become partially acclimatized to reservoir conditions before they have any opportunity to emigrate. The fish grow quickly, and about 40% of them are taken by anglers (Heimer 1984). He found 58% of the hatchery harvested were taken in the reservoir, and 42% were taken in the river below the dam.

Downstream movement of trout out of the reservoir may be influenced by reservoir conditions. With good conditions, a higher percentage of trout may stay in the reservoir. Emigration is not necessarily a problem because fish moving out contribute to the river fishery. Trout passing downstream, however, are subjected to turbine losses. If turbine mortalities are high, fish could be released in the river downstream to offset the losses. However, this would forego the growth that normally occurs in the reservoir, and fish released in the river would have to be raised to a larger size to provide a comparable fishery.

Yellow perch Perca flavescens are present in the reservoir, but few are taken by anglers. Catch in the river fluctuates from year to year. Causes of these fluctuations are unknown.

Shoreline habitat in the form of flooded or emergent vegetation is available only in protected reservoir areas. These include an area near the city of American Falls and in bays, such as Seagull Bay and Fairview Bay (between Little Hole Bay and the Dam). Riprap has been placed along the reservoir shoreline in selected erodible areas. At high water elevations, both are available as cover to fish. Due to drawdown, this habitat is available for only part of the year. Consequently, drawdown may have a major effect on reservoir fish populations. If cover is important for holding fish, the loss of it with drawdown should result in dispersal and reduced vulnerability to anglers. Even if good populations are present, fishing could be poor because fish are not concentrated. Virtually no habitat work in relation to game fish populations has been done at American Falls Reservoir. Specifically, the availability of structure or cover in relation to reservoir drawdowns is unknown.

OBJECTIVES

In 1988, we assessed reservoir trout habitat in relation to temperature and oxygen conditions during drawdown in a low water year. We had hoped that 1989 would be a normal water year, and repeated our work to compare habitat availability at low vs. normal pool elevation. Since large numbers of trout emigrate from the reservoir annually, we wanted to estimate turbine mortality to determine if these fish should be planted in the river. We also wanted to examine the role and availability of habitat for cover-orientated fish.

Specific objectives were as follows:

1. Describe seasonal trends in trout habitat based on dissolved oxygen and temperature.

2. Determine if trout habitat is influenced by reservoir drawdown.

3. Describe any relationships between trout habitat and trout fishing success and the apparent emigration of fish from the reservoir.

4. Describe the influence of habitat structure on fish density.

5. Describe the availability of shoreline habitat related to historic reservoir operations, and determine whether drawdown limits habitat availability for existing or potential game fish species.

6. Estimate the mortality of rainbow trout passing through a turbine at American

7. Determine the feasibility of using radio telemetry techniques to assess mortality of rainbow trout passing through turbines at American Falls Dam.

METHODS

Seasonal Trout Habitat

We hypothesized that dissolved oxygen and temperature conditions in American Falls Reservoir directly influence fishery. To assess this, we calculated trout habitat using methods outlined by Van Velson (1986). We defined Usable Trout Habitat (UTH) as water <19°C and dissolved oxygen >5.0 mg/L, and Maximum Trout Habitat (MTH) as water <21°C and dissolved oxygen >3.0 mg/L. Rainbow trout mortality usually does not occur when temperatures are cooler than 21°C and dissolved oxygen is greater than 3.0 mg/L (Threinen 1959). These are the same definitions used in 1989 (Heimer 1989).

We described oxygen temperature profiles at 1-meter intervals using a YSI Model 54A dissolved oxygen/temperature meter. We started sampling on June 6, 1989, and continued until September 27, 1989. We sampled biweekly at the same eight stations as in 1988 (Heimer 1989).

Influence of Reservoir Operations on Habitat

We assumed that lower pool volumes could result in shorter times to reach anoxia, therefore aggravating poor oxygen conditions. This effect would be due to a lower volume of oxygen available to sediment oxygen demand ratio (Reininger et al. 1983). We collected dissolved oxygen information over a 2-year period and constructed a model of oxygen consumption. We used the model to predict the effects of various environmental conditions on reservoir oxygen consumptions. Examples of these conditions are water levels, inflow or outflow, and initial oxygen concentrations necessary to reach limiting oxygen levels.

Oxygen Model

The model was virtually identical to the one developed by Reininger et. al. (1983) for Cascade Reservoir. To estimate parameters for our model, we partitioned the hypolimnial oxygen deficit (total oxygen consumption) among oxygen input from inflow, oxygen loss from outflow water column demand, and sediment demand. As water column consumption, oxygen inflow, and outflow vary as a function of pool volume, we estimated these parameters for each reservoir elevation observed during our sampling.

We calculated water column demand from biweekly samples collected between June 6 and September 1, 1989, using HOD techniques outlined in Standard Methods

(1985) but incubated in situ. The estimated mean decrease in oxygen in all the samples over time was multiplied by the mean depth to estimate water column demand as follows:

$$WCD = O_{2i} - O_{2dn}/days(z)$$

where:

WCD = Water Column Demand

O_{2i} = initial mean oxygen

O_{2dn} = mean oxygen at day n

z = mean depth

To estimate oxygen inflow, we sampled oxygen in the Portneuf River and the Snake River during the period June 9 to September 2, 1989. We sampled the Portneuf River at the Siphon Road Bridge and the Snake River at the Tilden Bridge. We calculated the oxygen volume of the inflow by multiplying the mean inflow (m^3 /sec) by the mean dissolved oxygen. We converted the results to g/m^3/day based on total reservoir volume.

We estimated sediment oxygen demand as the difference between the total oxygen deficit, water column demand, and estimates of tributary inflow and outflow through the dam as follows:

$$S = WCD - W_j - OF_j + IF_j$$

where:

S = Sediment oxygen demand

W_j = water column consumption at elevation j

OF_j = oxygen loss due to outflow at elevation j

IF_j = oxygen gain due to inflow at elevation j

Sediment oxygen demand was held constant in the model, as it should not vary appreciably with pool volume (Reininger et al. 1983). We obtained inflow and outflow records from the Bureau of Reclamation.

Dissolved oxygen in springs on the Fort Hall Indian Reservation were estimated from Bushnell (1969). Dissolved oxygen levels from 1969 were used instead of those reported for 1968, as conditions in 1989 and 1969 seemed more comparable. Oxygen conditions from the tributary springs on the Fort **Hall** Indian Reservation are available only for those two years.

We used the model to estimate the time necessary to consume all oxygen in the reservoir, assuming no input from primary production. We assumed that a reduction in time to anoxia with lower pool volume represented greater potential for stressful conditions or summerkill. Conversely, no change or an increase in time to anoxia with decreasing volume would represent no negative influence on oxygen availability by drawdown.

We estimated days to anoxia in the reservoir:

$$O_{t+1} = O_{ti} - S - WC + I - OF$$

where:

O_{ti} = initial total areal oxygen consumption (mg/m^3/day), mean reservoir D.O. + I - S - WC - OF

S = sediment oxygen consumption

WC = water column oxygen consumption (mg/m^3/day)

I = oxygen input due to tributary input (mg/m^3/day)

OF = oxygen loss due to outflow (mg/m^3/day)

Habitat Loss and Fishing Success

We assumed that as temperature and dissolved oxygen conditions deteriorated in the reservoir, fishing success could be affected. To describe any relationship between fishing and habitat availability, we checked reservoir catch rates from mid-June through late August. We censused reservoir anglers every other Saturday as they finished fishing. We censused river anglers every Saturday immediately downstream from the dam as they completed fishing.

We used correlation analysis and displayed catch rates and habitat data graphically to examine common trends.

Habitat Structure and Fish Density

We hypothesized that spiny ray fishes are not concentrated at any location in the reservoir because of a lack of habitat structure. We reasoned that populations may be strong but fishing poor because fish are not available or vulnerable to anglers. To test this, we sampled existing structures in the reservoir and also constructed artificial structures using willow trees Salix spp. We assumed that if structure was limiting the fishery, any new or existing structure should concentrate fish.

We constructed three structures, each 20-25 m across, on May 31, 1989. One structure, called Fairview Structure, was located in Fairview Bay 75 m from the east shoreline. Water depth at this location is 3.7 m. Another structure, called the East Structure, was placed along the shoreline approximately 3 km east from Fairview Bay and 125 m offshore from the high water mark. Water depth at this location at the time of placement was 4.9 m. This area had a sandy bottom, with the closest emergent woody vegetation approximately 1 km. The West Structure was along the shoreline, approximately 1.5 km east from Fairview Bay and offshore about 75 m from the high water mark. Water depth at the structure at the time of placement was 3 m. The shoreline at this location was riprapped previously by the U.S. Bureau of Reclamation to reduce erosion. The closest emergent woody vegetation was approximately 200 m.

We determined the fish species using the artificial structures by electrofishing at night. We sampled on a biweekly basis starting June 14. The West structure was out of water on July 10, and the remaining two were out on July 23 because of drawdown.

We also sampled three different shoreline habitats. One site was dominated by woody vegetation. The amount of cover at this site was reduced considerably as water levels receded. We used a second sampling site with a sandy shoreline and small sparse emergent willows. We used a rocky shoreline as our final sampling site. This site was characterized by a lava rock shoreline. The rock extended into the reservoir at all reservoir elevations, and thus was the only cover available to fish throughout the summer. The last area is called "Point of Rocks" by anglers.

We sampled each shoreline site using six replicates of 5 minutes and recorded all captured fish by species. We stopped at the end of each 5-minute interval and enumerated all captured fish. We collected as many fish as possible, with two people dip-netting during the sampling.

Shoreline Habitat and Reservoir Operations

As an alternative explanation of poor fishing, we hypothesized that production of game fish (spiny rays) is influenced by reservoir drawdown. To examine this hypothesis, we used aerial photography techniques to determine the amount of shoreline habitat that might be used for spawning and rearing by largemouth bass, crappie, and yellow perch. On June 21, 1989, we had aerial photos of the entire reservoir shoreline taken. The habitat quantity was estimated directly by measurement of shoreline length, with cover at the water surface (elevation 1325.40) and at the full pool mark. We assumed the active storage pool elevation (1327.25) as the highest shoreline point visible in the photos. We defined shoreline cover as any vegetation, riprap, or natural broken rock that was in the water.

We determined the linear percent cover at the two elevational levels. We used the relation between percent cover and reservoir elevation, and past mean elevation by date to estimate cover available by date in normal years. We assumed that a lack of cover during spawning or rearing periods would be an important limitation on production.

Turbine Mortality Assessment

To estimate survival of fish passing through the turbines we used recovery ratios of test (released into the turbine) and control (released below the dam) groups of rainbow trout. Survival (5) was calculated as follows:

$$S = Rt/Rr$$

where: Rt = number of fish recovered following release and passage through the turbine and

Rr = number of fish recovered following release in the river

Mortality (M) was calculated as: M = 1-S. We estimated mortality by pooling all recoveries and calculated the confidence limit as follows:

$$CI = 2 \sqrt{1-M(M)/n-1}$$

where n = the total number of fish recovered from both groups.

We also calculated the mean of the mortality from five paired releases and calculated the confidence interval of this estimate using the same method as the pooled estimate. Pooling the results weighs each recapture equally, whereas estimates on mean recovery rates of each recapture method would weight the recapture methods equally (Richard Inouye, personal communications, 1990). As number of recaptures for each method were unequal, weighing each recapture method is less statistically reliable than pooling recaptures. We also used a Wilcoxon sign-rank test to compare river-released and penstock-released fish, as this test makes no assumptions about similar sampling efforts on each release date. We made paired releases on five occasions at weekly intervals from June 27 to July 24.

Our method assumed: 1) any mortality related to handling or stress is equal in the two groups; 2) differences between recapture of penstock released fish and river released fish can only be attributed to passage through the turbine itself, therefore our estimate is not of mortality of fish passing from the reservoir to the river; and 3) avian predation is a part of turbine mortality. Control fish in our study experienced as much as possible the same set of conditions as test fish, with the exception of exposure to the turbine (see Cox 1958).

Recoveries were made by electrofishing and through the angler census. We compared return rate obtained from electrofishing to return rate from anglers to assess possible bias to sampling methods. We also maintained length records (at the time of planting) on planted and recaptured fish to assess possible size-selective mortality.

Both the penstock-released fish and the river-released fish were from the same raceway at American Falls Hatchery. Before tagging, the fish were anesthetized with MS 222. Fish were tagged with identical, size 6 monel, metal jaw tags differentiated by number. We measured each fish (total length). We attempted to duplicate sizes of reservoir fish passing the turbines as much as possible with our tagged fish. Test fish averaged 320 mm total length, while reservoir fish caught by anglers in late June and early July averaged 322 mm.

After tagging, we held all fish in live boxes for a minimum of 48 hours to check for mortality. The first two experimental groups were tagged and held for five days before planting. Because all mortality within the first groups occurred during the first 24 hours, we tagged the last three groups a minimum of 48 hours prior to release.

Releases of Test Fish

We released nearly equal numbers of penstock fish and control (river) fish in the penstock and river on each date. In all five cases, the numbers of fish in the two groups were within two fish of each other. On planting days, the releases were made 1-2 hours apart, with the penstock fish released first. We released all fish into turbine Unit 3 because of its accessibility. We assumed that the design of the three turbine units in the dam were identical (Idaho Power Company, 1973), that physical parameters associated with the different units were the same (i.e. flows, wicket gate openings), mortality at each unit would be the same, and that tests in Unit 3 would therefore be representative of all units.

To release fish in the penstock, we bolted together sections of PVC pipe having an inside diameter of 15 cm and lowered it in the gatewell down to the penstock. This technique was similar to that described by Taylor and Kynard (1985) . The pipe was lowered between 1 m and 2 m into the penstock and secured by rope and chain for the releases. A large funnel was attached to the upper end for ease in starting the fish into the pipe.

The water flow in the penstock was calculated by Idaho Power Company engineers at 4.9 m/sec. Since recommended maximum velocities for trout passing through culverts are not over 1.22 m/sec (Evans and Johnson, 1980), we assumed this flow prevented fish from moving upstream into the reservoir.

The first group of fish planted in the penstock and river were transported from the fish truck to the PVC pipe in dip nets. The next four groups were planted by using a plastic planting tube which was attached to the planting tank and extended into the PVC pipe. A 3.0 m section of PVC pipe was used for releases in the river to approximate penstock release conditions. Because of a Venturi effect, water and fish were pulled through the pipe. We do not believe any fish remained in the pipe. However, when the penstock planting was completed, the plastic tube was pulled out and a concrete plunger, about 5 mm in diameter smaller than the pipe, was lowered through to force any remaining fish into the penstock. We released the fish in the river on the Aberdeen side of the dam, immediately downstream from the Idaho Power Company security fence.

At American Falls Dam, three Kaplan turbines are present. They run at a speed of 150 rpm. Water flow through the turbines on the planting dates varied from 95 to 110 m^3/sec, and wicket gate openings from 60-72%. Spiral case pressure on the release dates was between 22 and 24 m of water.

To assess handling mortality, we used fish that had been tagged and held with each release group. We lowered these fish down the PVC pipe to approximately 1-2 m from the penstock. During the first three plants, we held the fish between circular concrete blocks placed 3.1 m apart on a chain. During the last two plants, we used a nylon net bag. Five fish were lowered down the pipe each plant, then retrieved and placed in a live box in the river. At approximately the same time, five fish from the hatchery were placed in the same live box. The two groups of fish were held for five days to assess handling mortality.

Tag Recovery

To facilitate tag recovery efforts, we posted signs at fishing access downstream from American Falls Dam advising anglers to return tags from fish caught in the area. On the first night following planting, we concentrated our electrofishing efforts in the first 1 km below the dam where we recaptured most fish. On one occasion we sampled in the Mary's Mine area, and another the Eagle Rock area, which are about 5 km and 10 km downstream from the dam, respectively. Actual electrofishing time each night varied somewhat depending on success, weather conditions, and equipment problems.

We were concerned that predation on the released fish by pelicans, that concentrated downstream from American Falls Dam, might bias our results. On the final release day, we discharged three cracker shells in the area downstream from the dam immediately following each of the two releases.

We used our estimate of turbine mortality, and previous estimates of hatchery fish recovery rates, to compare the relative benefits of releasing fish in the reservoir and the river.

We estimated survival of fish from the reservoir release to successful emigration to the river as follows:

$$S_r = (1 - E - M - C)\ S_t$$

where:

S_r = survival from release to the river

E = exploitation rate of hatchery fish in the reservoir

M = natural mortality rate (proportion) of hatchery fish in the reservoir

C = the proportion of hatchery fish that carry over from one year to the next in the reservoir

S_t = survival of fish passing through the turbines

We assumed that carryover fish either did not survive to emigrate, or did not emigrate in the second year. We also assumed that catchables were stocked in the reservoir at an average size of 150 g and cost $1.00/450 g to produce (Mike Larkin, personal communication, 1990). Because fish emigrate from the reservoir at about 450 g in size, we assumed that river stocking intended to compensate for turbine losses would be with 450 g fish, again costing $1.00 each.

Radio Telemetry Tags

We wanted to use radio telemetry tags to assess trout movement through the penstocks. Individual tags could be used to monitor individual fish movement. We hoped this approach would augment the mortality information collected by other methods.

We used tags with a frequency range of 30.17 MHz to 30.25 MHz. Each weighed 3.2 grams and was powered by a silver oxide battery. We tested tags having both whip and coil antennae. The tags were tested both in the air and in water.

Our tests of the tags indicated that their signal was not strong enough for our work. In open air, we could hear the signal only up to 50 m. We could not hear the signal through any more than 3-6 m of water, not enough distance to adequately track fish. The cause of the poor reception is unknown. We did not pursue this technique any further in 1989.

RESULTS

Seasonal Trout Habitat

Below average water years occurred in 1987, 1988, and 1989. The reservoir was drawn down more quickly, and carry-over water at the end of the irrigation season was extremely low (Figure 1). In October of all three years, the reservoir contained less than 155 x 10^6 m^3 of water, while the long-term average was 760 x 10^6 m^3. The volume of habitat in the reservoir was obviously reduced

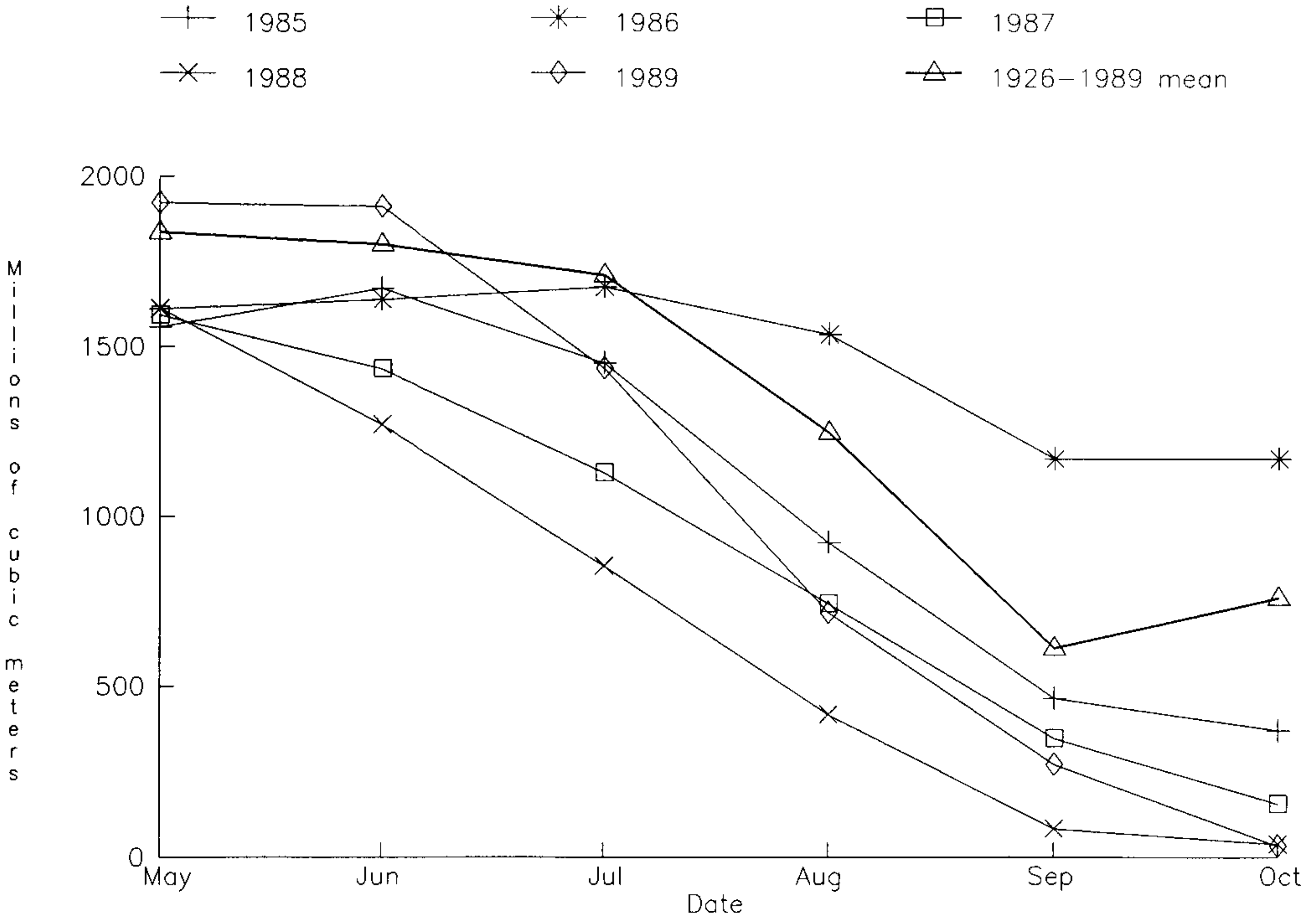


Figure 1. Storage volume at American Falls Reservoir, May 1 to October 1, 1985-89, and for the long-term average.

by drawdown during the last three low water years, without considering temperature and oxygen conditions.

Surface dissolved oxygen conditions ranged from 6.0 mg/L to 8.0 mg/L, and from 6.0 mg/L to 9.0 mg/L during the sampling periods in 1988 and 1989, respectively (Figure 2). We found the lowest dissolved oxygen concentrations near the bottom in July of both years. In 1988, mean reservoir surface temperatures were approximately 22°C for much of the sampling period (Figure 3). They increased to 21°C in mid-July, 1989, and dropped to 18°C in late August.

With the exception of a spike on August 4, 1989, secchi transparencies decreased throughout the sampling period (Figure 4).

In 1988, UTH as a percentage of full pool was less than 10% throughout the sampling period (Figure 5). UTH as a percentage of the available pool increased from August 11 to August 18 and stayed high. Temperature was typically the most important influence on UTH during 1989. In 1989, UTH as a percentage of full pool dropped rapidly in June, then stayed low throughout the remainder of the time. UTH as a percentage of available pool decreased rapidly in June but increased rapidly in late August. Low dissolved oxygen was the most important influence on UTH in June; high temperatures was the most important from July through mid-August.

We found trends in MTH similar to those for UTH (Figure 6). Available habitat declined from June to August. Although total habitat and pool volume remained low (% full pool), the quality of the available reservoir for trout increased dramatically during August.

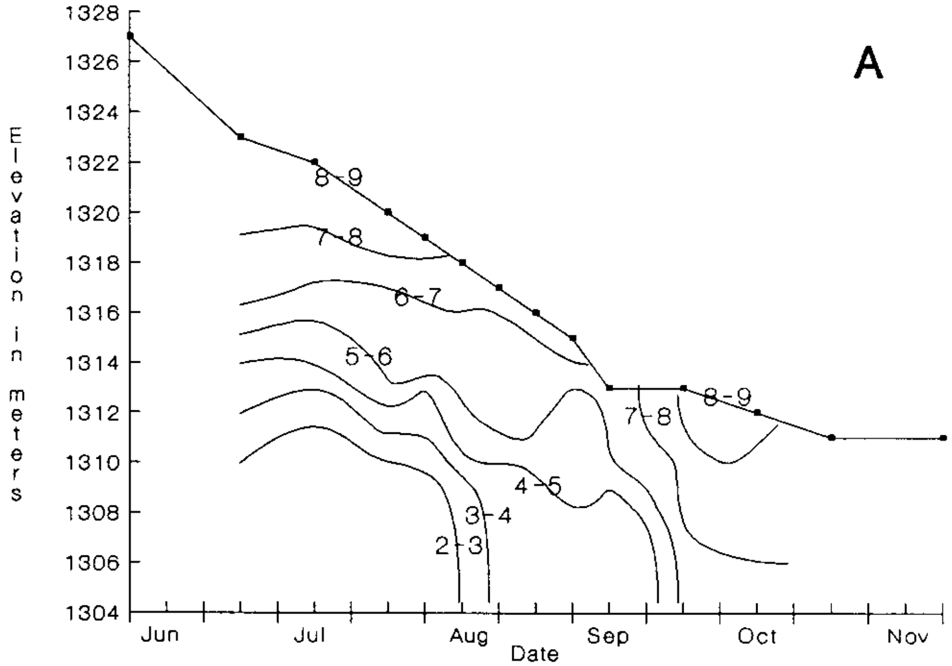
Influence of Reservoir Operations on Habitat

Oxygen Model

Analysis of our reservoir oxygen model was incomplete at the writing of this report.

Habitat Loss and Fishing Success

The highest reservoir catch rates occurred early in the season in 1988 and 1989 (Figure 7). In general, catch rates declined through the season. Overall anglers averaged 0.13 trout per hour and 0.51 trout per angler (Appendix A). Catch rates in the Snake River during the 1989 census period were high in late May, decreased in June, then increased throughout July. In general, the river fishery improved during July and declined in August (Figure 7). Overall, anglers averaged 0.37 trout per hour and 1.45 trout per angler (Appendix B). During the river census, we checked 832 hatchery rainbow, 31 rainbow trout of unknown



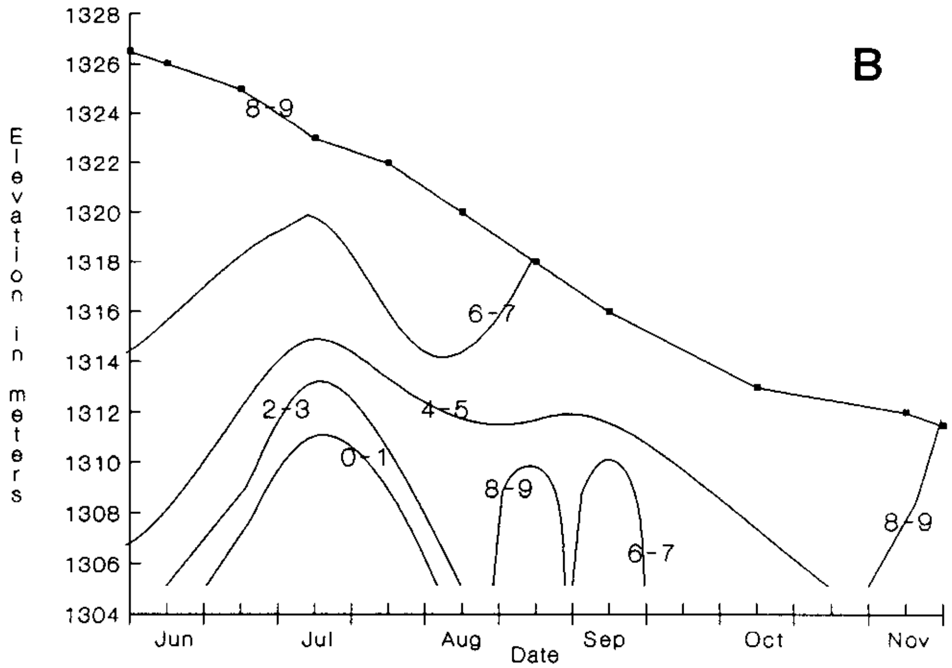


Figure 2. Mean dissolved oxygen isopleths (mg/L) at eight stations, American Falls Reservoir, A-1988, B-1989.

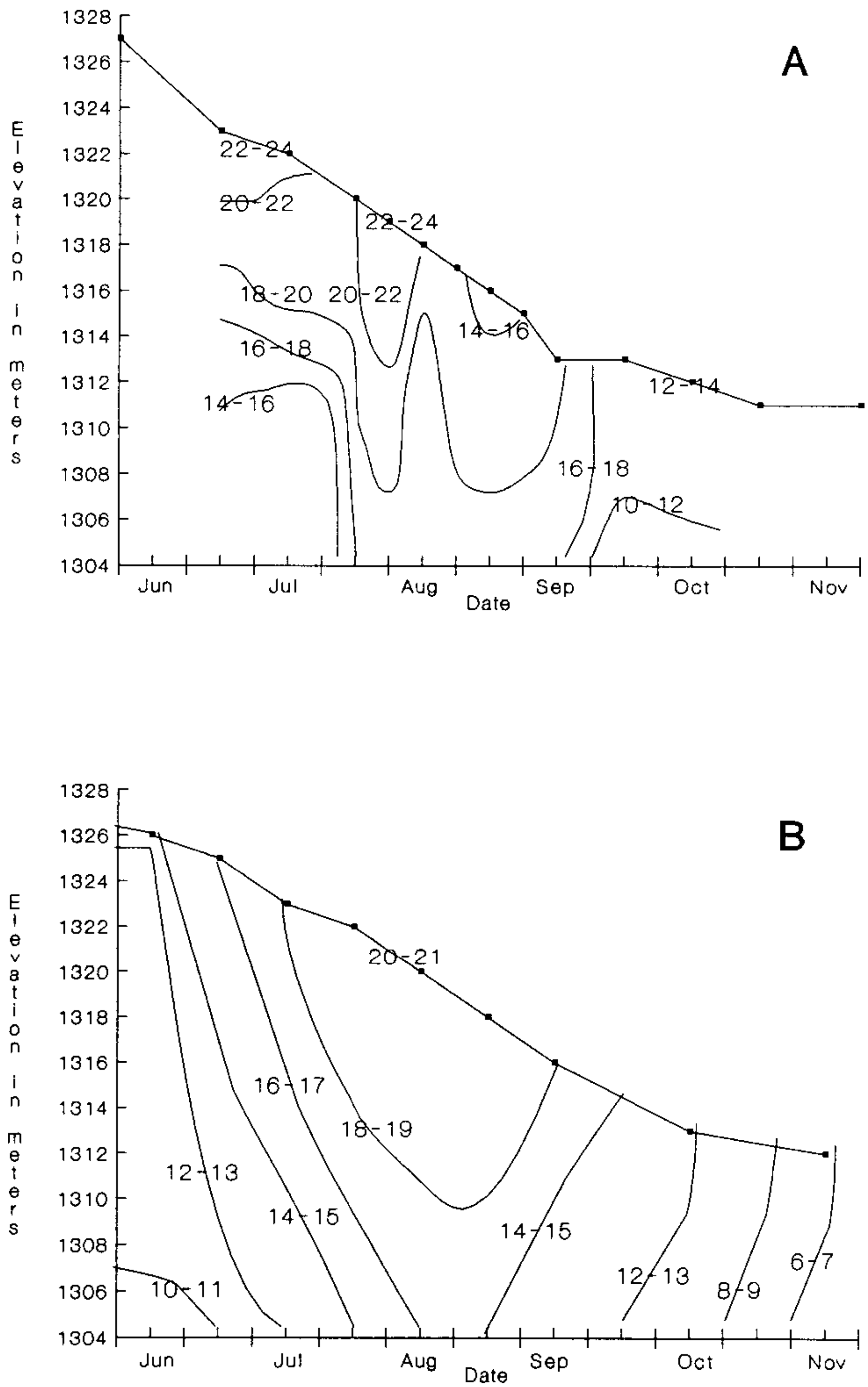


Figure 3. Mean water temperature isopleths (°C) at eight stations, American Falls Reservoir, A-1988, B-1989.

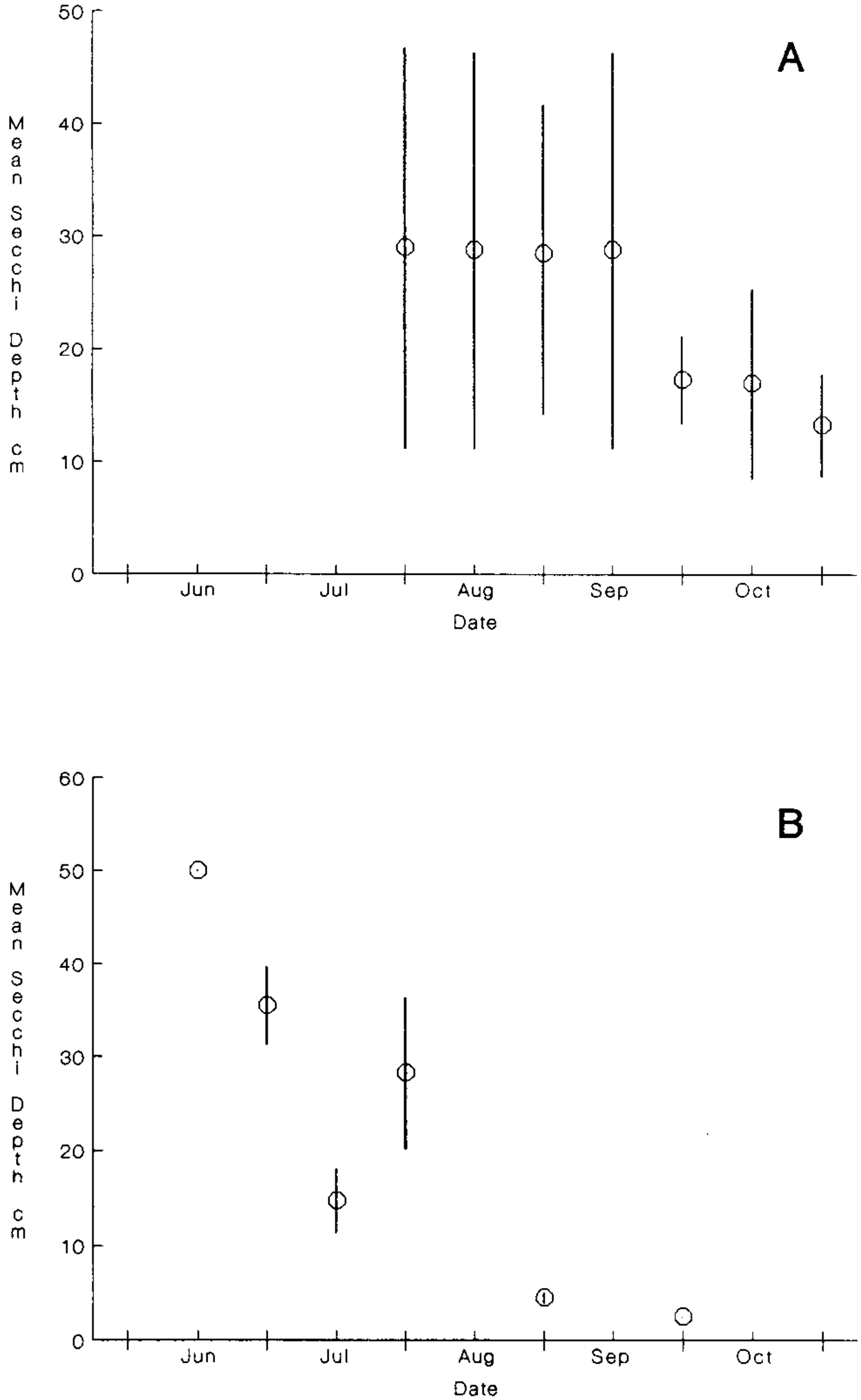


Figure 4. Mean secchi transparency for eight stations, American Falls Reservoir, A-1988, B-1989.

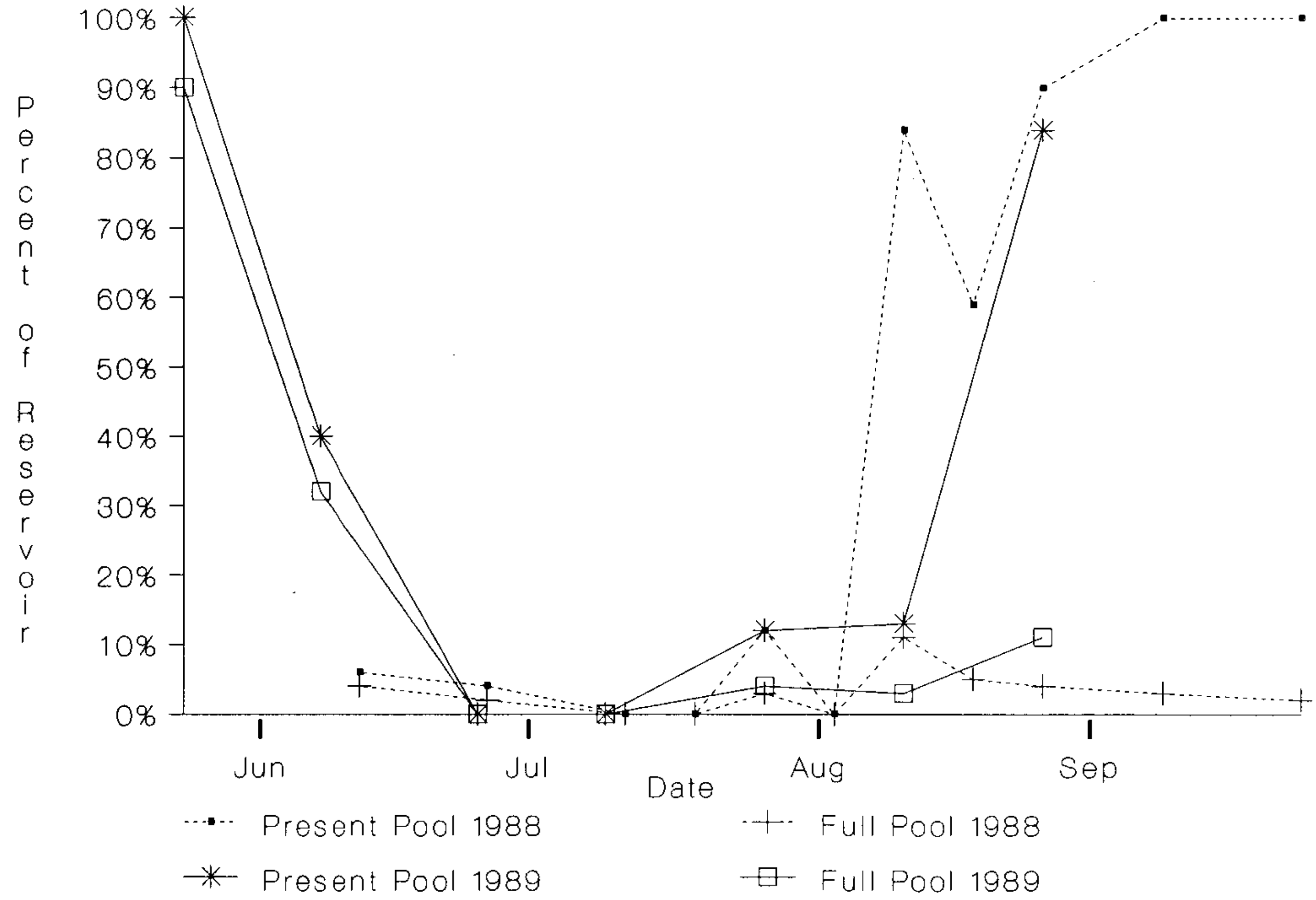


Figure 5. Percent Usable Trout Habitat (UTH) in American Falls Reservoir in 1988 and 1989. UTH was defined as dissolved oxygen greater than, or equal to 5.0 mg/L and temperature less than, or equal to 19°C.

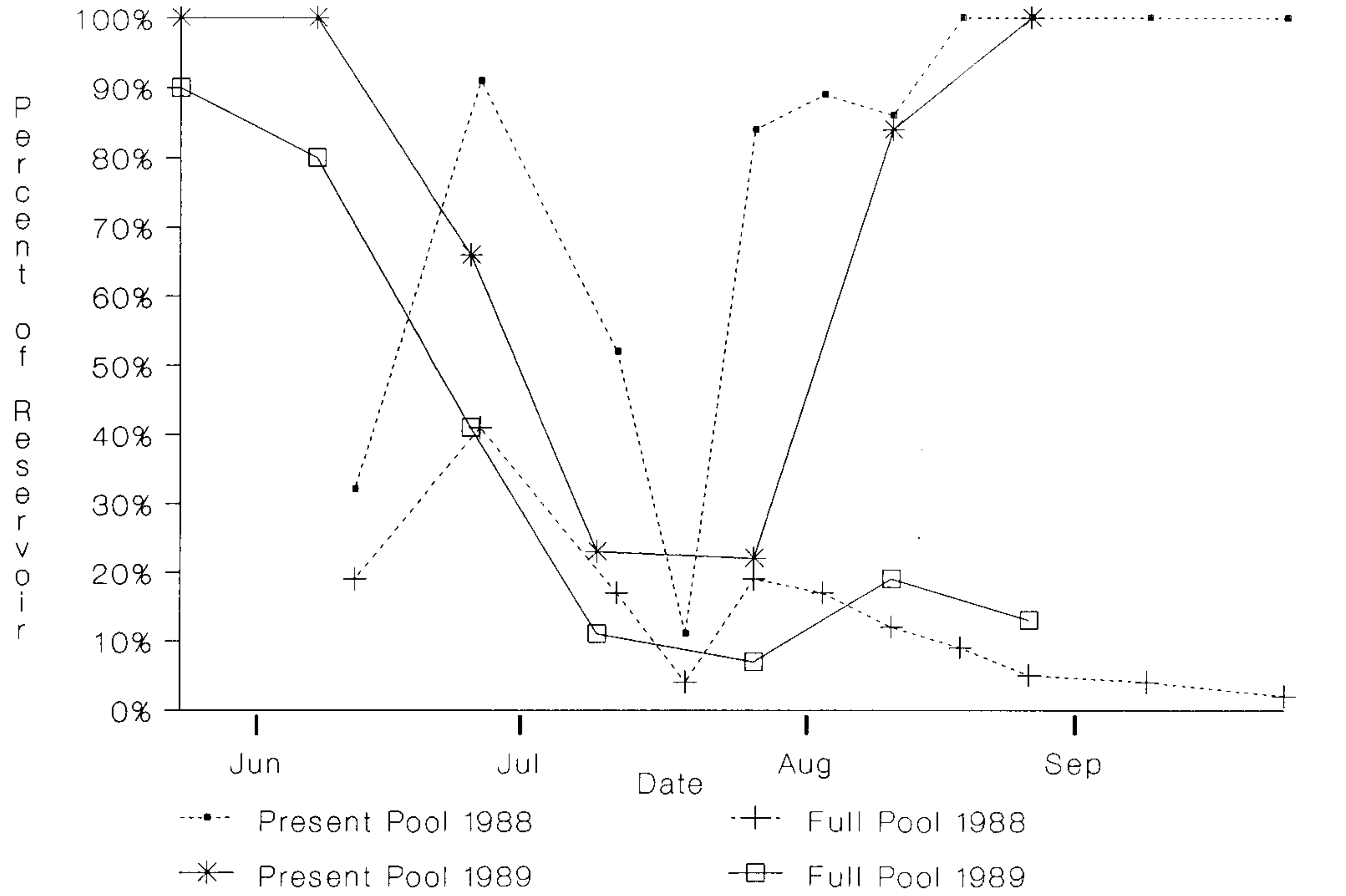
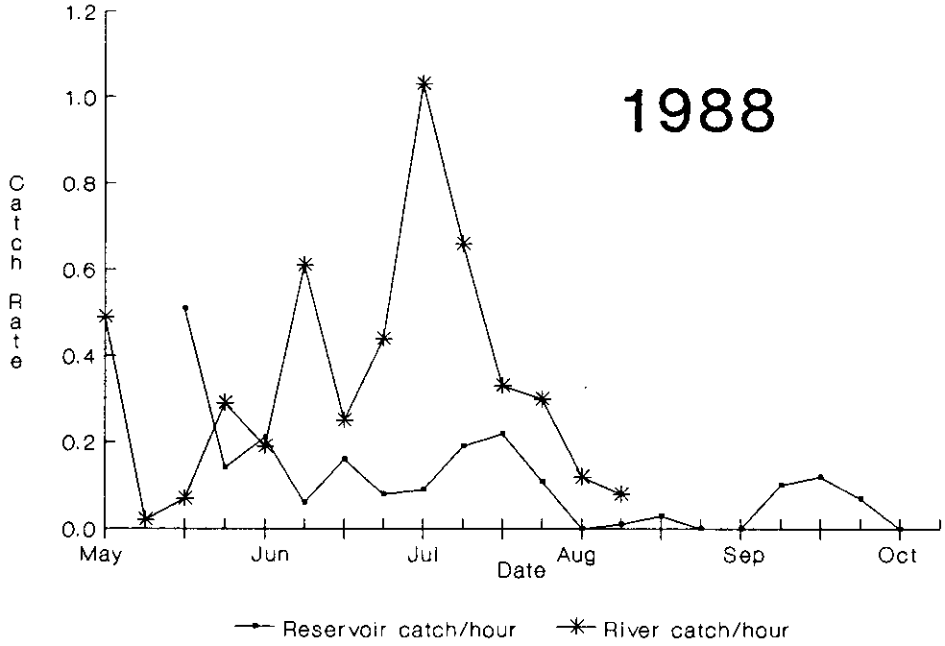


Figure 6. Percent Maximum Trout Habitat (MTH) in American Falls Reservoir in 1988 and 1989. MTH was defined as dissolved oxygen greater than, or equal to 3.0 mg/L and temperature less than, or equal to 21°C.



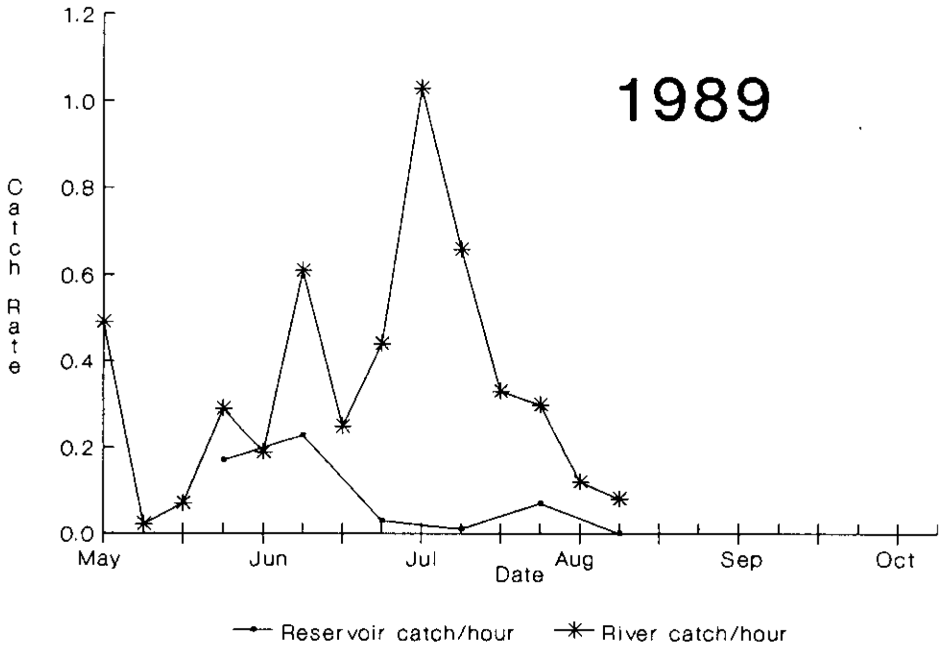


Figure 7. Catch rates of hatchery rainbow trout by anglers at American Falls Reservoir and the Snake River downstream for 1988 and 1989.

origin, 8 cutthroat, and 9 brown trout. We did not see any yellow perch or black crappie.

Mean total length of hatchery rainbow caught by anglers from the Snake River decreased from May through July, then increased again in August (Appendix C). The mean total length of reservoir fish taken by anglers in June and July was nearly identical.

We found no meaningful correlations between catch per angler in the Snake River below the dam and trout habitat in the reservoir. We found no correlation between the reservoir catch rates and trout habitat. We found no correlation between river catch rates and reservoir catch rates, but in general, catch rates in the reservoir declined as catch rates in the river increased in both 1988 and 1989 (Figure 7). All correlation results are summarized in Appendix D.

Habitat Structure and Fish Density

On June 14 and 28, 1989, we sampled all artificial structures and did not capture or see any fish. On July 10, we captured one black crappie Pomoxis niqromaculatus and saw three adult carp Cyprinus carpio at one structure. On that date, one structure was out of the water. On July 23, the remaining structures were out of the water.

Natural Habitat

During the shoreline sampling, we captured 1,870 fish. Of this total, 44% were Utah suckers Catostomus ardens and 25% yellow perch Perca flavescens (Figure 8). Redside shiners Richardsonius balteatus, Utah chubs Gila atraria, and carp Cyprinus carpio made up the remainder.

The majority of Utah suckers captured were found along the rocky shoreline, while the majority of yellow perch were found in the woody vegetation along the sandy shoreline (Figure 9). Redside shiners were common in all three habitat types.

Virtually all yellow perch captured were less than 5 cm in length and assumed to be young-of-the-year fish. Only two perch were over 10 cm.

Shoreline Habitat and Reservoir Operations

At full pool (elevation 1,327.25 m), we measured a shoreline distance of 154. 0 km, with 88% having habitat in the form of woody vegetation, natural rock, or riprap (Table 1, Figure 10). On June 21, 1989, the day the photographs were taken, surface elevation was 1,325.40 m. Shoreline distance was 151.4 km with 63% cover. The loss of shoreline with woody vegetation was most pronounced.

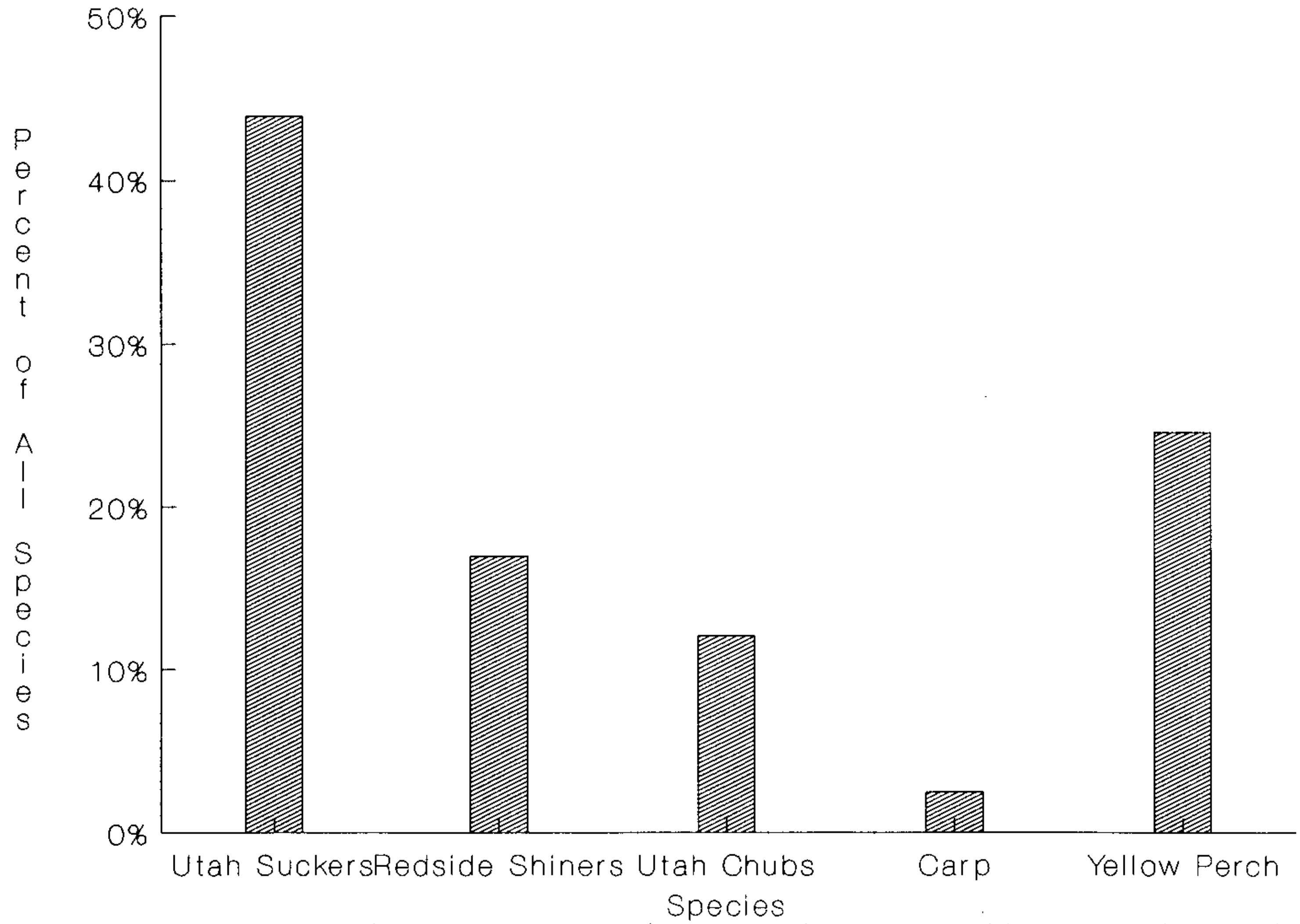


Figure 8. Fish species (percent of all fish) captured by electrofishing at American Falls Reservoir, 1989.

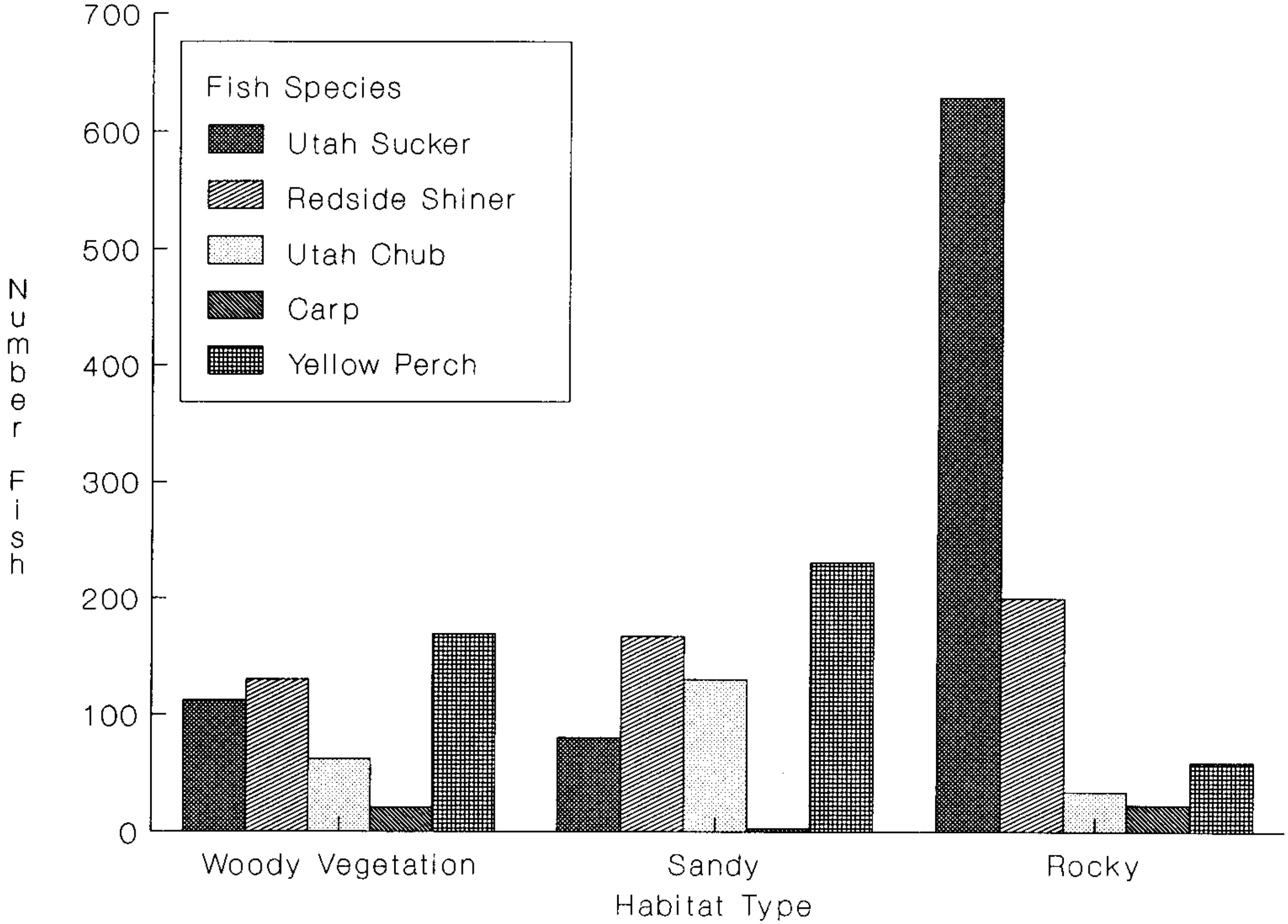


Figure 9. Number of different fish species captured by electrofishing in three habitat types, American Falls Reservoir, 1989.

Table 1. Percent of different habitat types at two water levels at American Falls Reservoir.

Pool level (m)	Shoreline distance (km)	Percent		
		Vegetation	Natural rock	Riprap
1327.25	154.0	52.8	22.2	13.3
1325.40	151.4	29.3	23.9	9.8

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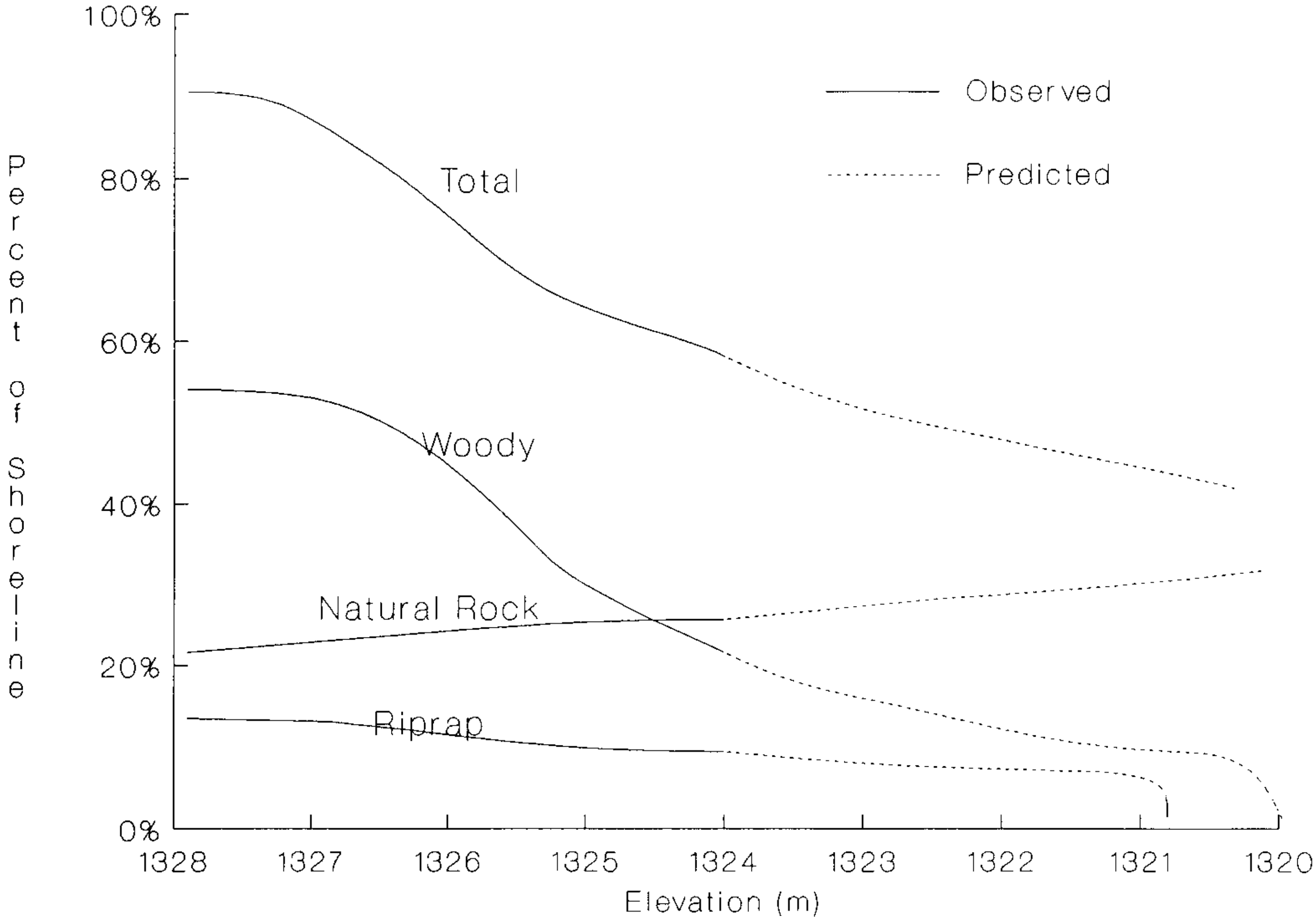

Figure 10. Percent of riprap, natural rock, and woody habitat found along the shoreline of American Falls Reservoir.

Percent of shoreline with natural rock cover actually increased with drawdown (Table 1). We did not sample at lower pools, however.

If we assume the same percentage changes in woody habitat (as occurred between elevation 1,327.25 m and 1,325.40 m) (Figure 11), all should be lost between elevation 1,323 m and 1,322 in. The reservoir normally reaches this elevation around mid-August. The amount of habitat in the form of natural rock should also decline. We believe it would drop sharply at elevation less than 1,325 m because most natural rock is in the form of lava flows at that elevation or higher. Habitat in the form of riprap could be expected to drop to 0% at elevation 1,321, as it was placed to prevent shoreline erosion only at high water levels and also be unavailable by early August.

Turbine Mortality Assessment

To assess turbine mortality, we released 1,983 tagged fish and had returns from 128 (Table 2). Of this total, 52 were from the penstock plants and 76 from the river plants. There was a significant difference in recovery rate for the two combined groups of fish ($P>.05$, $x^2=4.50$, df=1). Estimated survival was .684 (52 penstock returns + 76 river returns). Confidence interval for the estimate was ± .083, or 12% of the estimate. Using the Wilcoxon sign-rank test in each of the five releases, both the number and percentage of river-released fish recovered was greater than the number of penstock-released fish recovered, providing a statistically significant difference of $p=0.03$. Of the 128 returns, 66 were obtained by electrofishing and 62 from anglers. The mean survival of the five different individual estimates was .660 ± .096, or about 10% of the estimate. There was no significant difference between return rates from the two sampling methods ($P<.05$, x^2 =.13, df=1). An independent T test on length by location indicated there also was no significant difference between total length of fish released in the penstock and river ($P=.071$). There was no significant difference in length between fish released in the penstock and those penstock-released fish recaptured by anglers and electrofishing ($P=.304$ and $P=.625$), respectively. Most fish were in the 310-339 mm length class (Figure 12).

As a result of our injection methods, we lost one fish due to unknown causes and one due to being caught between the plunger and pipe wall while pulling the plunger up. We did not lose any of the control group. We tested a total of 25 trout from each group. The trout lost due to our mechanical recovery methods would not have been subjected to the same methods during our actual releases. Therefore, we can assume that one of the two mortalities would not have occurred. We assume the cause of the other was the result of handling.

Estimation of parameters in our calculations to determine if we should release fish in the reservoir or river were based on data from Reimer (1984). He estimated total first-year recovery of hatchery releases (reservoir and river) from 32% to 43%. Approximately 60% of the recoveries were made in the reservoir. We, therefore, assumed that exploitation in the reservoir ranges from 0.19 to 0.26. We estimated carry-over from actual tag recoveries of each release group in the reservoir over 2 years. Those estimates ranged from 0.08 to 0.12. For

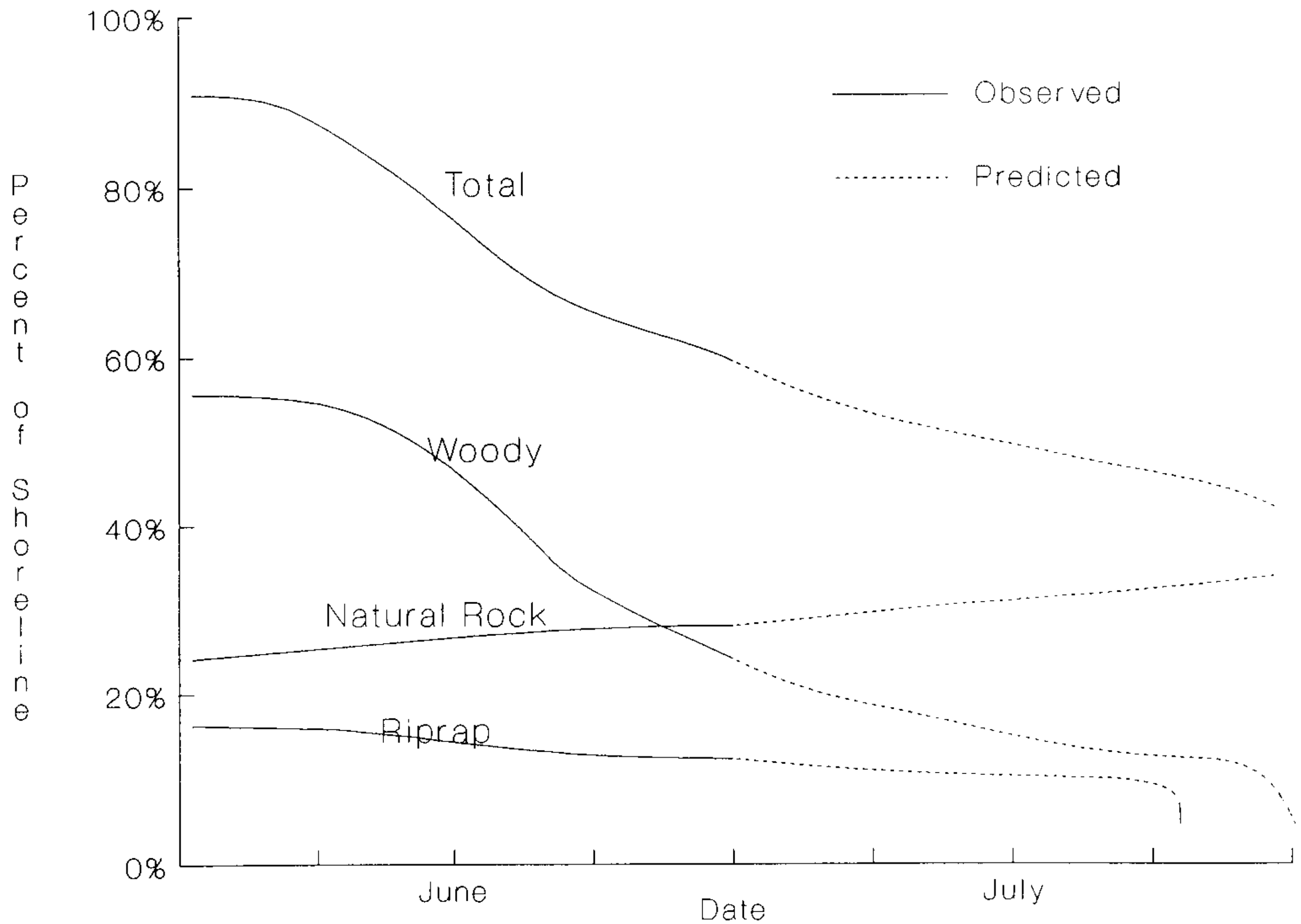

Figure 11. Percent of shoreline containing different habitat types during a mean water year at American Falls Reservoir.

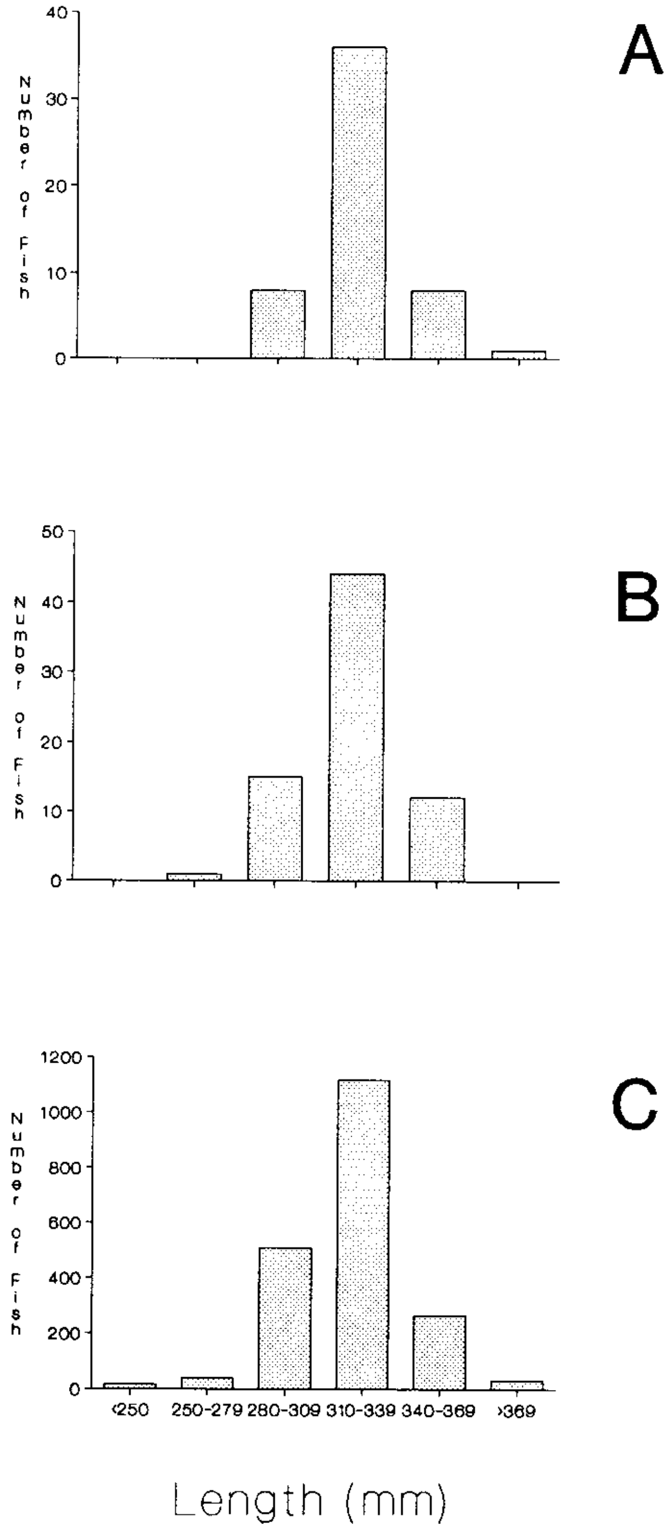

Figure 12. Length frequency of test fish released in the penstock (A), control fish released in the Snake River (B) and penstock released fish recovered by anglers and elecrofishing.

Table 2. Number of test and control fish released and returns from anglers and by electrofishing, American Falls Dam, 1989.

Date released	Location released	Number released	Number returned by method: anglers	electrofishing	Total
June 27	Penstock	118	5	2	7
June 27	River	119	8	6	14
July 5	Penstock	250	6	7	13
July 5	River	249	8	9	17
July 12	Penstock	249	9	8	17
July 12	River	251	6	12	18
July 17	Penstock	248	6	0	6
July 17	River	250	13	1	14
July 24	Penstock	125	0	9	9
July 24	River	124	1	12	13
Totals		1,983	62	66	128

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turbine mortality we used our estimates derived earlier. We had no way to estimate mortality in the reservoir. However, by accounting for other losses and recoveries, the maximum mortality may not be greater than 0.40, and may be substantially less. We assumed a range of 0.0 to 0.4 for our calculations. We estimate a mean cost of $1.06, with a range of $0.69 to $2.28 per fish to provide a 450 g fish in the river through reservoir stocking. The reservoir alternative compares favorably with the direct stocking cost of $1.00 per 450 g (see Table 3 for a summary of parameter estimates). This depends on reservoir exploitation, natural mortality, and carry-over. Reservoir stocking also provides the recreational opportunity to harvest these fish before they emigrate to the river.

DISCUSSION

Seasonal Trout Habitat

Low water years during the two years of this study resulted in lower than normal reservoir elevations. Consequently, we were not able to evaluate what might happen during a more normal or high water year, since anticipated reservoir habitat conditions deteriorated early in the summer in both years. By August, however, habitat conditions within the existing pool improved. In relation to full pool, conditions dropped and stayed low. This was because total volume was low. Reservoir drawdown in both 1988 and 1989 appeared to have a positive influence on dissolved oxygen. The improvement in water quality with decreasing pool volume may have been due to increased mixing and the increased influence of tributaries (i.e. lower flushing time).

This may not be the case during a normal water year when stratification could be more prominent. Stratification of the reservoir is more likely at higher pool elevations. Our data suggests that summer kill resulting from hypoplimnetic anoxia should be rare at low pool elevations because stratification will not persist long enough for oxygen to be depleted.

Our results suggest that reservoir drawdown causes a loss in trout habitat, primarily through the loss of reservoir volume. Drawdown may actually enhance water quality in the remaining habitat. Drawdown does not appear to seriously aggravate problems related to marginal oxygen or temperature.

Habitat Loss and Fishing Success

Rainbow trout normally concentrate in front of American Falls Dam in late July and early August. Depending on trout concentrations, fishing can be good during this period, though we observed a general decline in catch rates for the

Table 3. Parameter values for comparison of benefits between reservoir and river stocking of hatchery fish.

Parameter	Low estimates	High estimates
E	0.19	0.26
M	0.0	0.4
C	0.08	0.12
St	0.66	0.66
S	$0.69	$2.28

Estimates assume an initial cost of hatchery fish at $0.33 per fish ($1.00 per 2.2 kg and 3 fish per 2.2 kg).

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reported that 58% were taken in the reservoir, while 42% were from the river downstream. We conclude that emigration from the reservoir determines the timing and numbers of fish available to the anglers on the river. Poorer habitat conditions on the reservoir may produce better fishing in the river.

Habitat Structure and Fish Density

Lynch and Johnson (1988) evaluated different types of artificial structures and determined that structures of a type similar to ours would concentrate fish. We captured only one black crappie while sampling either the artificial structures or shoreline areas. We feel that large numbers of crappie were present in the reservoir and some concentration should have occurred at the artificial structures or in association with the shoreline cover. We believe this indicates a very low population present in the reservoir in 1989.

The fact that we did not catch any other game fish at our structures indicates that additional habitat structures of the type we used would not influence fish density or angler success. We conclude that factors other than fish concentration are influencing fishing success at the reservoir.

We found yellow perch in each of the three different habitat types samples. Overall, they made up 25% of the total number of fish caught. Their numbers increased considerably during the sampling period (June 14 to August 7), but virtually all fish captured were young-of-the-year. Since few larger yellow perch were captured during our sampling or by anglers, we suspect that few adult perch were present in the reservoir. Other studies (Jarmon 1973; Johnson et al. 1976) have suggested stronger populations in American Falls Reservoir in the past. More detailed work specifically directed to yellow perch will be necessary to determine what factors are controlling that population.

Shoreline Habitat and Reservoir Operations

The amount of habitat in the form of woody shoreline vegetation available for fish drops quickly in late June, and continues to drop throughout the irrigation season. Assuming the same loss of woody habitat continues with elevational drops, we would expect virtually no woody shoreline habitat at elevation 1,323.0 m. During a normal water year, this occurs around August 5.

Habitat in the form of natural rock along the shoreline actually increases with a 2.6 m drop in elevation from high pool, because as the water recedes it exposes lava rock at lower elevations. However, one major lava flow near the lower end of the reservoir extends to the old river channel. Riprap placed to reduce shoreline erosion is virtually nonexistent as water levels drop past the 1,324.0 m level. Little cover should be available in American Falls Reservoir after early August in a

Krieger et al. (1983) evaluated different habitat criteria important for yellow perch. They developed eight suitability index (SI) values for yellow perch, rating them on a scale of 0.0 to 1.0, with 1.0 having or providing the highest or best conditions for survival. Values approaching 1.0 (the highest) were associated with percent cover in littoral areas and between 20% and 50%. This cover was in the form of vegetation, brush, debris, or standing timber during the summer. They also assumed that at least 25% vegetative cover would be necessary for optimum habitat suitability. Cover in the form of woody vegetation may limit yellow perch at American Falls Reservoir. We expect cover of that form to be less than 25% by mid-July in normal water years.

Edwards et al. (1982) listed 12 important SI habitat criteria for black crappie Pomoxis nigromaculatus in a lacustrine environment. They reported the highest SI values occurred when percent cover in the form of vegetation, brush, debris, or standing timber varied between 25% and 85% during the summer. Vegetation and woody or other debris was almost associated with spawning nests. Again, at American Falls Reservoir during an average water year, less than 25% of the shoreline has suitable cover for black crappie after mid-July. Turbidity may also be a problem during a low water year for black crappie (Edwards et al. 1982). Transparency declined substantially in late summer and fall during 1988 and 1989, probably as a result of increased suspended sediment and faster mixing times. Headcutting associated with tributary mouths may also aggravate this in low water years (Reimer 1989). We do not have measurements of actual turbidity to compare with SI values. Better information will be necessary to determine whether turbidities are a factor limiting crappies.

We believe smallmouth bass populations might be established at the reservoir. Edwards et al. (1983) listed 13 important SI values for smallmouth bass. The authors list spawning temperatures as best between 18°C and 20°C, which occurs at the reservoir in late June. Growing season (May-October) temperatures are optimum between 20°C and 30°C. In late June, the lower range of these temperatures occur. Substrate consisting of broken rock with crevices and fissures have the highest suitability index. At high reservoir pool elevation, natural rock and riprap occurred along 35% of the shoreline. After almost a 2-meter drop in elevation, rocky habitat still occurred along 34% of the shoreline. This was because lava rock along the shoreline and around the islands became exposed with decreasing elevational levels. One major lava flow, locally called "Point of Rocks," continued to the low pool elevation observed in 1989. Thus some habitat should be available at virtually any pool elevation. The total amount of habitat will still be influenced by drawdowns. In most years, the amount of habitat available for smallmouth will be low through much of the summer. Although smallmouth may be established, the population should be small and localized.

Turbine Mortality Assessment

We estimated that 67% of the fish introduced to the penstock of American Falls Dam successfully entered the river downstream. Thus, we can expect a mortality rate of 33% for fish of the size that normally pass the dam in late

July or early August. This problem was recognized by the Idaho Power Company when they reconstructed the dam, as their hydropower license requires reservoir plants of 4,500 kg of hatchery rainbow trout annually. With the simple migration model we developed, predictions on numbers of fish reaching the river which can be calculated considering such factors as reservoir mortality, turbine survival, and percent of trout in the reservoir emigrating.

Survival estimated as the mean of five release experiments was .665. The 95% confidence interval for the estimate was ± .084. We felt the precision of our estimate was good. Increased precision can be achieved by more marks or more returns. If we doubled the number of fish planted (to 4,000) and assumed the same mortality rate, we could expect the confidence interval to be .316 ± .058. A release of 6,000 fish would result in a confidence interval of ± .047. Considering equal survival if we doubled returns to 256 fish, we could expect our confidence interval to be reduced to + .058.

A number of factors can effect the accuracy of results in turbine mortality studies. These include fish species, size, condition, dissolved atmospheric gases, temperature, test procedures, and controls (Eicher et al., 1987). Site factors, such as turbine type, head, runner elevation, cavitation efficiency, wicket gate opening, and shear can also influence mortality. Consequently, a mortality rate at one hydroelectric facility may be different than at another.

Stocking fish directly into the river does not appear to be a cost effective approach to improve river fishing. The benefits of growth in the reservoir are comparable to, or outweigh, the costs of turbine mortality, unless turbine mortality is much higher than we estimate. Our analysis of stocking alternatives also did not consider the benefits from fish harvested in the reservoir. Therefore, we conclude that there is no reason to stock fish directly in the river. Emigration of rapidly growing fish from the reservoir is the most effective means of supporting the river fishery.

SUMMARY AND CONCLUSIONS

Reservoir drawdowns the past two drought years appeared to have a positive, rather than negative, effect on reservoir temperature and oxygen. As the reservoir pool was lowered, dissolved oxygen increased. The reservoir did not stratify strongly, probably because of increased mixing with lower pool volume. During a more normal water year, we might expect more stratification than occurred in 1989 and perhaps a greater risk of summer-kill.

Artificial structures did not concentrate game fishes during the period we sampled. We conclude there are few game fishes present which would concentrate at additional structures if constructed.

We caught few adult yellow perch during our sampling at the reservoir. Anglers were not successful in catching this species. It appears that adult numbers are extremely low, even though 25% of the fish taken during the shoreline sampling was young-of-the-year yellow perch.

Oxygen and temperature conditions in American Falls Reservoir were marginal for rainbow trout. They probably cannot be improved under current reservoir operation constraints. Alternative trout strains better suited to higher temperatures may provide better carryover in the reservoir and, thus, better utilize the productive environment.

Habitat in the form of shoreline vegetation decreases rapidly with drawdown. During many months of the year, there is virtually no habitat in the form of vegetative cover available to game fish species. Some natural rock cover is available even at lower pool elevations; result of a natural lava flow.

Drawdowns seriously limit the potential of warmwater and coolwater species associated with vegetative cover along the shoreline. Smallmouth bass may find abundant forage, but any introduced population will be limited by shoreline cover during much of the year. Other species that are not dependent upon cover may be better suited to this reservoir.

An alternative to new species introductions may be to construct a smaller stable reservoir within the reservoir by damming a bay. We recommend that preliminary engineering studies be conducted on potential sites where reservoirs could be created in existing bays. Two potential sites are Fairview Bay and Little Hole Bay. A small reservoir with a stable water level would probably provide a considerable amount of fishing opportunity for catchable trout and spiny ray fishes and provide more total cover than is available in the entire reservoir at low pools. The turbine mortality study at American Falls Dam should be discontinued. We feel that our results reflect trout losses at American Falls Dam as accurately as possible. Injection techniques and recapture methods are accepted ways to assess passage mortality (Eicher et al. 1987). Sizes of fish used for the mortality studies were similar to those caught at the reservoir during that period of time. Mortality of fish used to test our injection methods was also low (1 out of 25).

RECOMMENDATIONS

1. Continue limnological studies at American Falls Reservoir when a normal water year is expected. The last two years have shown what conditions are like during low water. Another low water year is expected in 1990.

2. Artificial structures failed to attract game fish. We should not attempt to create additional game fish holding cover without solving apparent limitations in spawning and rearing cover/habitat related to drawdown.

3. Do not stock trout directly in the Snake River below American Falls Dam. Turbine mortality is a factor *which* probably cannot be changed. Turbine mortalities could be circumvented by planting trout of the desired size in the river. However, this would ignore the growth obtained by the hatchery fish in the reservoir and the opportunity for a reservoir fishery.

4. Trout strains better suited to the high reservoir temperatures should be considered for introductions. Temperature and oxygen conditions in the reservoir appear marginal for the different strains of rainbow trout planted to date. This includes Mt. Whitney and Mt. Lassen rainbow trout, as well as those from the Department's Hayspur Hatchery. We do not believe that high temperature and low oxygen conditions for trout can be improved substantially through changes in reservoir operations under current irrigation drawdowns.

ACKNOWLEDGEMENTS

Dave Streubel and Doug Taki helped with the collection of the data, and Bruce Rieman with study design and review. Personnel from both the U.S. Bureau of Reclamation and the Idaho Power Company helped with the penstock injection of fish and tag recovery efforts, respectively. Personnel from American Falls Hatchery provided equipment and help when needed. Richard Inouye of Idaho State University helped with the statistical analysis.

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LITERATURE CITED

American Public Health Association, American Water Works Association, Water Pollution Control Fed., 1985. Standard Methods for the examination of water and waste water, American Public Health Association, Inc. Washington D.C.

Bushnell, V.C. 1969. Eutrophication investigations of American Falls Reservoir. U.S. Bureau of Reclamation, Pacific Northwest Region.

Cox, David A. Planning of Experiments. Wiley and Sons, 1958.

Edwards, E.A., D.A. Krieger, M. Bacteller, and O.E. Maughan. 1982. Habitat suitability index models: Black crappie. U.S.D.I. Fish and Wildlife Service. FWS/OBS-82/10.6.

Edwards, E.A., G. Gebhart, and O.E. Maughan. 1983. Habitat suitability information: Smallmouth bass. U.S.D.I. Fish and Wildlife Service FWS/OBS-82/10.36.

Eicher Associates, Inc. 1987. Turbine-related fish mortality: review and evaluation of studies. Project 2694-4, Final Report to the Electric Power Research Institute. November 1987. Portland, Oregon.

Evans, W.A., and B. Johnston. 1980. Fish Migration and Fish Passage. U.S.D.A. Forest Service, Washington, D.C. 20013.

Heimer, J.T. 1984. American Falls-Snake River Fisheries Investigations. Idaho Department of Fish and **Game** Job Report. Project F-73-R-3. Final Report to Idaho Power Company. Boise, Idaho.

Heimer, J.T. 1989. American Falls Reservoir Studies. Idaho Department of Fish and Game Job Report, Project F-71-R-11. Boise, Idaho.

Idaho Power Company. 1973. American Falls Power Plant-Environmental Statement, Boise, Idaho.

Jarmon, T.L. 1973. Mercury accumulation in yellow perch Perca flavescens correlated with age and growth. M.S. Thesis, Idaho State University, Pocatello, Idaho.

Johnson, D.W., D. Campbell, and C. Kent. 1977. **Availability** and concentration of pollutants from American Falls Reservoir sediments to forage and predaceous fishes. Idaho Water Resource Research Institute. Technical Completion Report, Project A-043-IDA, Moscow, Idaho.

Krieger, D.A., J.W. Terrell, and P.C. Nelson. 1983. Habitat suitability information: Yellow perch. U.S.D.I. Fish Wildlife Service. FWS/OBS-83/10.55. Washington, D.C.

Lynch W.E. and D.L. Johnson. 1988. Bluegill and crappie use of nearshore structure. Final Report. Ohio Department of Natural Resources. Project F-57-R, Study 10. Columbus, Ohio.

Reininger, B. et al. 1983. Cascade Fishery Investigations. Idaho Department of Fish and Game. Job Performance Report. Project F-73-R-4, Subproject III, Boise, Idaho.

Taylor R.E. and B. Kynard. 1985. Mortality of juvenile American shad and blueback herring passed through a low-head kaplan hydroelectric turbine. Transactions of the American Fisheries Society 114:430-435.

Threinen, C.W. 1958. Cause of mortality of a midsummer plant of rainbow trout in a southern Wisconsin lake, with notes on acclimation and lethal temperatures. Progressive Fish Culturist. 20:27-32.

U.S. Bureau of Reclamation. 1979. American Falls Reservoir, Area Capacity Table. Boise, Idaho.

Van Velson, R.C. 1986. Techniques for measuring summer trout habitat in coolwater reservoirs of Colorado. Colorado Department of Natural Resources Fishery Information Leaflet Number 38. Project F-60-R. Denver, Colorado.

APPENDICES

Appendix A. Monthly effort and catch rate of hatchery-released rainbow rainbow trout by anglers fishing American Falls Reservoir, 1989.

Month	Anglers checked	Hours fished	Fish caught	Fish per Hour	Fish per Angler
July	81	321	60	.19	.74
July	68	265	24	.09	.35
August	23	84	4	.05	.17
Totals	172	670	88	.13	.51

Appendix B. Monthly effort and catch rate of hatchery-released rainbow trout by anglers fishing the Snake River downstream from American Falls Dam, 1989.

Month	Anglers checked	Hours fished	Fish caught	Fish per Hour	Fish per Angler
May	256	1,129	556	.49	2.17
June	173	581	73	.13	.42
July	68	286	143	.50	2.10
August	71	244	50	.20	.70
Totals	568	2,240	822	.37	1.45

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Appendix C. Mean total lengths of hatchery rainbow trout caught from the Snake River and American Falls Reservoir, 1989.

Month	Location	Sample size	Mean length
May	River	241	390
June	River	66	344
July	River	70	323
August	River	34	343
June	Reservoir	35	322
July	Reservoir	11	323

Appendix D. Summary correlation results for habitat loss and fishing success.

Catch per angler in river vs. MTH in reservoir:
$r = 0.652$, $P = 0.012$

Catch per angler in river vs. UTH in reservoir:
$r = 0.446$, $P = 0.110$

Catch per angler in reservoir vs. MTH in reservoir:
$r = 0.382$, $P = 0.593$

Catch per angler in reservoir vs. UTH in reservoir:
$r = 0.279$, $P = 0.593$

Catch per angler in river vs. catch per angler in reservoir:
$r = 0.23$, $P > 0.05$

APP89

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